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Relationship and prediction of body weight from morphometric traits of indigenous highland sheep In Tigray, Northern Ethiopia

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The study was conducted in Atsbiwonberta district to determine the relationship between live weight and linear measurements and predict live weight from morphometric traits. Three potential peasant associations namely, Habes, GolgolNeale and Gebrekidan were selected. Randomly selected 257 sheep (121 males and 136 females) were grouped into four age groups (0 PPI, 1 PPI, 2 PPI, and 3 PPI). Live body weight was highly and significantly (P<0.01) correlated with heart girth (0.950), body length (0.788) and height at wither (0.785). The simple regression equation for prediction of live body weight using heart girth was y = -18.7+0.6*HG (R^2 0.903; P<0.000; N=257). The multiple regression equation for prediction of live body weight using heart girth, body length and height at wither was y = -24.3+0.5*HG+0.2*BL (R^2 0.983; P<0.000; N=257) and y=-25.5+0.5*HG+ 0.1*BL+0.1*HW (R^2 0.995; P<0.000; N=257). The current study concluded that heart girth or its combinations could provide a good estimation for predicting live weight of highland sheep.

Key words: Highland sheep, body measurement, prediction equation.

INTRODUCTION

The increased human population coupled with recurrent unpredictable climatic conditions uncertainty of weather conditions and crop failures resulted in upsurge in demand for livestock products. The report of Thornton (2010) corroborated this submission that the contribution of livestock for food production is increasing at a higher rate than that of cereals in developing countries. The estimated population of cattle, sheep, and goat in Ethiopia was estimated as 53.4, 25.5 and 22.78 million, respectively (CSA, 2011). The report of earlier study by the Institute of Biodiversity Conservation (IBC) on documentation of breeds of small ruminants in Ethiopia indicated the general overview of the indigenous small ruminant breeds inhabited in Ethiopia. Fourteen breeds of sheep and 15 breeds of goat inhabited in the low land, midland, and in highland agro ecologies of the country

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(IBC, 2004). Abergelle, Begait, Ille and highland sheep are the four sheep breeds inhabited the regional government of Tigray under varied agro ecological zones including lowland, midland and highland (Zelealem et al., 2012). The highland sheep breed found in Atsbie district is characterized as small breed with an average live body weight of 28 and 23 kg for adult (≥3 years and above) male and female sheep, respectively (Weldeyesus and Yayneshet, 2016). Breed improvement through selection under smallholder farmer is important for ensuring sustainable improvement of the indigenous sheep breeds. Body measurements especially body length, heart girth and height at wither were used to described the population sheep breed. The three linear body measurements mentioned above are the most important criteria used for selection of individual sheep (Weldeyesus and Yayneshet, 2016). Live body weight is also used as criteria for performance evaluation of the individual animal. However this fundamental knowledge of obtaining direct body weight measurements at the field level has practical limitations due to the time and energy expended while determining. Indirect estimation of body weight to an acceptable degree of accuracy using a prediction equation based on linear body measurements is of considerable practical use. Thus, regressing body weight on linear body measurements can be a method of weighing animals without weighing scales. The aim of this study was to evaluate the relationship between live body weight and linear body measurements of the highland sheep under study. The objectives of the study were to determine the relationship between live weight and linear body measurements in the highland sheep and to determine the best fitted regression model for prediction of live weight under field conditions.

MATERIALS AND METHODS

Description of the study area

The study was carried out in Atsbiwonberta districts of Ethiopia. Atsbiwonberta district is geographically located between 390 30' E to 390 45' E and 130 30' N to 130 45' N in eastern Zone of Tigray about 75 km northeast of Mekelle with an altitude ranging from 1800 to 3000 m above sea level with average an annual rainfall and temperature 667.8 mm and 18ºC, respectively (Mulata, 2013). About 75% of the district is upper highlands (2600 meter above sea level or above) while only 25% is found in midlands (between 1500 and 2600 m above sea level) and lowlands (below 1500 m above sea level) (Alembirhan; personal communication held on August 26, 2014). The dominant agricultural production system in Atsbiewonberat is mixed crop-livestock production with production with barley, wheat, pulses and small ruminants (sheep) as the principal agricultural products dominant sheep production (Solomon et al., 2010, 2013).

Sampling procedure

Random samples of 257 sheep (121 males and 136 females) were used to take linear body measurement of the highland sheep found in Atsbiwonberta. Three representatives Peasant Associations (PAs) namely; Habes, Golgolnaele and Gebrekidan were selected. The age of the sampled animal was determined using the dentations with the absence or presence of Paired Permanent Incisor (PPI). Accordingly, the randomly selected animals were grouped into four age groups namely: 0 PPI (4-12 months), 1 PPI (13-18 months), 2 PPI (19-25 months) and 3 PPI (above 25 months) consisted of 90, 45, 38 and 84 animals, respectively and in to two sex groups male and female. The recording procedures were adopted from FAO (2012) and Ethiopian Sheep and Goat Productivity Improvement Program (ESGPIP) (2009a,b) guidance.

Data collection

The variables measured included live weigh recorded using Salter scale with capacity of 50 kg (accuracy to the nearest 200 g) and while the linear body measurements morphological parameters were taken using tailor's tape calibrated tape rule (1.5 m and accuracy 0.5 cm). The measurements were taken in the morning were recorded early in the morning, with the animals standing on a flat surface with head held up. The following 12 linear body measurements namely, heart girth (HG), height at withers (HW), height at rump (HR), shoulder width (SW), body length (BL), chest depth (CD), ear length (EL), and ear width (EW), horn length (HL), tail length (TL), head width (HeW) and head length (HeL) were recorded for all of the sampled animals.

1. HG was measured as the circumference of the body immediately behind the shoulder blades in a vertical plane, perpendicular to the long axis of the body.
2. HW was measured as the distance from the ground to the withers
3. BL was the distance from the head of humerus to the distal end of the pubic bone.
4. SW was measured as a distance between the shoulders.
5. CD was measured as the distance between the top behind the scapular and the flow of the sternum (taken to be the depth of brisket) immediately behind forelegs.
6. HL is the length of the horn measured from nodule of the horn of the animal
7. EL is the length of the ear measured from nodule of the ear of the animal
8. EW is the distance between the two edges of the ear of the animal
9. TL is the length of the tail measured from nodule of the tail of the animal
10. HED is the distance between the two edges of the head of the animal
11. HEL the distance measured from nodule of the horn to the upper lip of the animal

Statistical analysis

Live body weight and Linear body measurement traits were subjected to multivariate analysis of variance using the General Linear Model (GLM) procedure of SPSS 16.0 with sex and age as fixed effects. Significant means were separated using the Duncan's New Multiple Range Test. Live body weight was regressed on linear body measurements using stepwise multiple linear regression analysis. Stepwise multiple regression procedure was used to select the number of predictors of live body weight based on the probability of F- statistics used as a criteria for entry ($P<0.05$) and removal ($P>0.10$) of the multiple stepwise regression analysis. The coefficient of determination (R^2) was used to assess the accuracy of prediction equations between live body weights and linear body measurements. The goodness of fit (R^2) and correlation coefficient (r) were tested to determine the contribution of each of the 12

Table 1. Coefficient of correlation between body weight and linear body measurements of the highland sheep.

	BW	HG	HW	RH	SW	BL	CD	E L	Ew	HL	TL	HeW	HeL
BW	1												
HG	0.950**	1											
HW	0.785**	0.621**	1										
RH	0.609**	0.539**	0.594**	1									
SW	0.429**	0.395**	0.366**	0.316**	1								
BL	0.788**	0.588**	0.722**	0.539**	0.362**	1							
CD	0.307**	0.297**	0.229**	0.289**	0.216**	0.223**	1						
E L	0.239**	0.224**	0.212**	0.291**	0.130*	0.183**	0.194**	1					
Ew	0.177**	0.176**	0.127*	0.184**	0.100	0.103	0.219**	0.137*	1				
HL	-0.025	-0.038	0.050	0.033	0.076	-0.016	-0.030	-0.148*	0.137*	1			
TL	0.396**	0.360**	0.351**	0.345**	0.363**	0.356**	0.169**	0.091	0.001	0.073	1		
HeW	0.318**	0.267**	0.284**	0.336**	0.161**	0.310**	0.215**	0.071	0.150*	0.188**	0.082	1	
HeL.	0.124*	0.089	0.131*	0.192**	-0.177**	0.175**	0.104	0.081	0.064	-0.067	0.134*	0.235**	1

**Correlation is significant at the 0.01 level (2-tailed); * Correlation is significant at the 0.05 level (2-tailed).

independent variables measured to the prediction of the dependent variable:

$Y_{ijk} = \mu + S_i + T_j + (ST)_{ij} + e_{ijk}$ ……………….Model 1 (Multivariate analysis of variance)

$W = a + b_1G_1 + b_2G_2 + …… + b_nG_n$ …………Model 2 (Stepwise Multiple linear regression)

$W = a + bG$)……………………….........Model 3 (Linear regression equation)

Where: Y_{ijk} = The dependent variable (body weight and 12 linear body measurements); W = The observation on live body weight of the animal; µ = Overall mean; S_i = Fixed effect of sex (i = Female, Male); T_j = Fixed effect of age (j = 0 PPI, 1PPI, 2PPI, ≥3 PPI); $(ST)_{ij}$ = the interaction effect of sex and age; e_{ijk} = effect of random error; a = Y Intercept; b = Regression coefficient of weight on body measurements; G = Body measurements; n = n^{th} number of body measurement.

RESULTS AND DISCUSSION

Coefficient of correlation between body weight and linear body measurements

The correlation of body weight and linear body measurements of the highland sheep was summarized from Table 1. It was observed that live body weight was positively, strongly and significantly (P<0.01) correlated with heart girth (0.950), body length (0.788) and height at wither (0.785 and height at rump (0.61). The correlation value of heart girth, body length, and height at wither to body weight in the current study is comparable to the previous research work done by Seare et al. (2010) found for Abergelle sheep. This report of the current finding is also similar to the previous research work done by Alemayehu and Tikabo (2010) found for the highland sheep. Afolayan et al. (2006) indicated that highest correlation coefficient (0.94) was found between heart girth and body weight in Yankasa sheep of found in Nigeria*.* All the linear body measurements except horn length positively correlated with body weight (Table 1). This finding is comparability similar to the finding of Afolayan et al. (2006). The study results indicated that heart girth, body length and height at wither were the three major linear body measurements with strong and positive correlation with body weight of the highland sheep.

Prediction equation for live body weight using HG, BL, and HW

The model for predicting live weight from body measurements of highland sheep were presented in Table 2. The regression equation indicated that heart girth alone is appropriate to estimate live body of the highland sheep with a coefficient of determination (R^2) of 0.90 for overall sex and age. The highest coefficient of determination was obtained when the equations were fitted for the pool age (Table 2). The report of the current study is in line to the work done reports of Younas et al. (2013) for Hissardale sheep found in Pakistan. The simple regression equation for prediction of live body weight using heart girth was y = -18.7+0.6*HG (R^2 0.903; P<0.000; N = 257). The multiple regression equation for prediction of live body weight using heart girth, body length and height at wither was y = -24.3+0.5*HG+0.2*BL (R^2 0.983; P<0.000; N = 257) and y = -25.5+0.5*HG+ 0.1*BL+0.1*HW (R^2 0.995; P<0.000; N = 257). Kassahun (2000) found out that heart girth alone explains 83 and 81% of the change in live body weight in Menz and Horro ram lambs. Thiruvenkadan (2005) suggested that "higher association of body weight with heart girth was possibly due to relatively larger contribution in body weight by heart girth".

The combination of the three linear measurements explained the variation of live body weight (98 to 99%)

Table 2. Models for prediction of live weight from body measurement and their R^2 adj values.

Age		N	Model	R^2 adj	P-value
0 PPI		90	-13.8 + 0.5*HG	0.712	P<0.000
			-23.8 + 0.5*HG +0.2*BL	0.929	P<0.000
			-24.3 + 0.5*HG +0.2*BL+0.1*HW	0.977	P<0.000
1 PPI		45	-20.8 + 0.6*HG	0.824	P<0.000
			-25.7 + 0.5*HG + 0.2*BL	0.979	P<0.000
			-27.1 + 0.5*HG + 0.2*BL+0.1*HW	0.993	P<0.000
2 PPI		38	-16.7 + 0.6*HG	0.758	P<0.000
			-21.2 + 0.5*HG + 0.2*BL	0.957	P<0.000
			-24.4 + 0.5*HG + 0.1*BL + 0.1*HW	0.992	P<0.000
3 PPI		84	-25.8 + 0.7*HG	0.877	P<0.000
			-25.5 + 0.5*HG + 0.2*BL	0.979	P<0.000
			-25.5 + 0.5*HG + 0.1*BL+0.1*HW	0.994	P<0.000
All age groups	M	121	-26.4 + 0.7*HG	0.930	P<0.000
			-25.2 + 0.5*HG + 0.2*BL	0.990	P<0.000
			-26.4 + 0.5*HG + 0.1*BL+0.1*HW	0.996	P<0.000
	F	136	-11.7+0.48*HG	0.940	P<0.000
			-17.5+0.49HG+0.11BL	0.967	P<0.001
			-26.4 + 0.5*HG + 0.1*BL+0.1*HW	0.992	P<0.001
Over all	M and F	257	-18.7 + 0.6*HG	0.903	P<0.000
			-24.3 + 0.5*HG + 0.2*BL	0.983	P<0.000
			-25.5 + 0.5*HG + 0.1*BL+0.1*HW	0.995	P<0.000

in the highland sheep. The current study suggested that heart girth or its combinations could provide a good estimation for predicting live weight of highland sheep.

Conclusion

In conclusion, since the body measurements had positive and high correlation with body weight indicating that body measurements can be used for estimation of body weight in the field where scales are not usually available. Moreover, heart girth, body length, and height at wither strongly and positively correlated with body weight. The live body weight of the highland sheep breed could be estimated based on the linear body measurements. Heart girth is the easiest way to use for live weight estimation at farm conditions especially under the smallholder farmers. These may also be used as selection criteria. However, further research is needed to investigate the relationship between the body weight and linear body measurements in other breeds of sheep and goats in Ethiopia.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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